Chemical Quality and Sediment Content of Runoff Water from Southeastern Montana Rangeland

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Abstract

Chemical quality of surface runoff water from rangeland sites with fine-textured soils in southeastern Montana was good to excellent with average total dissolved solids <300 mg/liter. This quality is better than that of most municipal water supplies in the same geographic area. Erosion from these sites was also low, averaging <1,500 kg/ha per year.

Surface runoff stored in small ponds is the main water supply for range livestock in the northern Great Plains because most streams are ephemeral and suitable groundwater is too deep for economical well drilling. Most previous investigations have studied quantity rather than quality of stock water supplies, but Soiseth (1975) reported that runoff and reservoir water quality in southeastern Montana was good to fair, and that the chemical quality of water stored in ponds could deteriorate to poor during the grazing season as water levels decrease by evaporation.

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The objective of the study reported here was to assess the chemical quality and sediment content of runoff water from fine-textured rangeland soil in southeastern Montana.

Site Description and Methods

This study was conducted about 29 km south of Ekalaka in southeastern Montana. The climate is arid to semiarid continental, with cold, dry winters and warm summers. Average annual precipitation is about 300 mm.

Runoff samples were collected from 10, 0.8-ha watersheds—eight on claypan range site where the average slope is 1 to 5% and two on a saline-upland range site where the average slope is 3%. Soils of the claypan range site are in the Bickerdyke and Bascovy series, which are members of the very fine and fine, respectively, montmorillonitic, Borollic Vertic Camborthids. The soils of the saline-upland range site are in the Dilts series, a member of the family of clayey, montmorillonitic, acid, frigid, shallow Ustic Torriorthents. Vegetation on the claypan site included thickspike wheatgrass (*Agropyron dasystachyum*), western wheatgrass (*A. smithii*), Sandberg bluegrass (*Poa secunda*), junegrass (*Koeleria cristata*), big sagebrush (*Artemisia tridentata*), and pricklypear cactus (*Opuntia polycantha*). Blue grama (*Bouteloua gracilis*), buffalograss (*Buchloe dactyloides*), and clubmoss (*Selaginella densa*) dominated small residual pedestals of coarse-textured material. On the saline-upland range site, alkali sacaton (*Sporobo-*

Table 1. Runoff water quality.

	Saline-upland range site						Claypan range site					
	Unfurrowed			Furrowed			Unfurrowed			Furrowed		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Elec. conductivity, mmhos/cm	0.58	0.10	0.23	0.83	0.30	0.42	0.35	0	0.06	0.13	0	0.06
Manganese, mg/liter	0.07	0	0.02	0.02	0	0.01	0.07	0	0.01	NR ²	NR	NR
Iron, mg/liter	17.30	0	3.00	0.05	0	0.02	9.16	0.39	1.80	NR	NR	NR
Calcium, mg/liter	0.59	0.01	0.22	*	*	1.52	0.15	0	0.04	0.10	0.05	0.08
Magnesium, mg/liter	0.47	0.01	0.11	*	*	0.49	0.04	0	0.01	0.03	0.02	0.03
Sodium, mg/liter	7.50	1.10	3.30	*	*	13.40	1.52	0.45	0.88	1.76	0.78	1.30
Total dissolved solids, mg/liter	390	0	100	600	160	250	200	0	10	20	0	7
Sediment, mg/liter	3615	315	1650	3835	710	1670	1085	95	390	660	215	370

¹ Results from one sample.² NR = No record.

lus airoides), Nuttall alkaligrass (*Puccinellia airoides*), and Nuttall saltbush (*Atriplex nuttallii*) were the dominant plants. Half of the watersheds at each site were contour furrowed with a RM-25 (Vallentine 1971) contour furrower. Runoff samples were collected by automatic pumping-type samplers that drew samples at 10-minute intervals during each runoff event. These samples were analyzed by routine laboratory procedures to determine electrical conductivity, major cations, and sediment content. Total dissolved solids were computed from the equation:

$$\text{TDS} = 0.819(\text{EC}) - 86.9 \quad [1]$$

where:

TDS = total dissolved solids in mg/liter, and
EC = electrical conductivity in micromhos/cm at 25°C.

Equation [1] has a correlation coefficient equal to 0.99 and was developed (Soiseth 1975) from water samples collected during a study in the same general geographic area in 1971-1973.

Samples were collected from all of the unfurrowed watersheds, but only two of the furrowed watersheds produced runoff, because rainfall during this period of record did not exceed the furrow water storage capacity on the other three furrowed watersheds during any single storm.

Results and Discussion

I collected more than 300 water samples during runoff events in 1977 and 1978. About 1/3 of these were randomly selected for initial laboratory analysis to determine whether the amount and range of chemicals were great enough to justify analyzing all samples. Results from 97 samples are summarized in Table 1. Since each of the subsamples was well within acceptable quality standards and since the ranges of values in the subsamples were relatively narrow, I decided that it was unnecessary to analyze the remaining 200 samples to assess the runoff water quality.

Runoff events from the contour furrowed watersheds were few, so the results shown for these watersheds represent fewer samples than do the results for the unfurrowed watersheds. In addition to the tests shown in Table 1, I also tested a few samples for nitrate nitrogen and phosphate phosphorus. The maximum amount of nitrogen measured in any sample was 0.06 mg/liter, and the nitrogen content of most samples was only a trace. The phosphorus content was less than 0.2 mg/liter.

Because no single ion tested or measured was present in harmful amounts, the best way to describe the quality of this water is by total dissolved solids (TDS). Soiseth (1975) presented a table that defined livestock water quality as "good" if the TDS value is between 0 and 1,000 mg/liter while others (Stephenson 1973; Wetchert and Freeman 1970) listed 5,000 mg/liter dissolved solids as the upper limit for consumption by livestock. Of the samples reported here, even those with the highest concentrations (600 mg/liter) are well below this upper limit. In fact, these samples are of better quality than many of the domestic and municipal water

supplies in eastern Montana. For example, the TDS in the municipal water supply in Sidney, Montana, is 1,000 mg/liter; in Baker, Montana, it is 1,200 mg/liter; and in Ekalaka it is 600 mg/liter.

There is some indication that the salt content of runoff water increases with increasing contributing area. The TDS of samples collected in June 1977 from the 0.8-ha experimental watersheds averaged about 150 mg/liter; a sample from Buffalo Creek, with a drainage area of about 4,000 ha, taken in May 1977, had about 600 mg/liter; and a sample from Box Elder Creek, with a drainage area of about 260,000 ha, also taken in May 1977, had about 850 mg/liter. The samples from the larger drainage areas were taken during a time of relatively high discharge and the concentrations probably increased during the season as the flow subsided.

Contour furrowing did not affect the sediment concentrations of samples from either the saline-upland or the claypan range site. On the saline-upland site, sediment concentrations averaged about 1,700 mg/liter from both the furrowed and the unfurrowed areas. On the claypan site, they averaged about 400 mg/liter. These concentrations represent sediment yields of about 170 kg/ha per cm of runoff from saline-upland range site and about 40 kg/ha per cm of runoff from the claypan range site. Converting these concentrations to annual yield values results in the estimates that the long-term average annual sediment yield from the saline-upland range site will not exceed 1,400 kg/ha per year from the native range uplands and 650 kg/ha per year from the contour-furrowed areas. Comparable values for the claypan range sites are 225 and 120 kg/ha per year. These values compare favorably with the rangeland soil loss tolerance of 4,500 kg/ha per year established by the U.S. Department of Agriculture (U.S. Dep. Agr., Resources Conservation Act Coordinating Committee 1980; Wight and Sid-doway 1980).

Because these values are so low, other erosion characteristics are of little more than academic interest, since it is questionable how applicable these results are to other areas with higher erosion rates. However, there are two observations that I should note.

1. Sediment concentration appears to be much lower during periods of snowmelt than during periods of rainfall runoff. This is only an indication because in most cases the sediment samplers were not operating during snowmelt periods because of the possibility of equipment damage from freezing. However, runoff samples were taken during two snowmelt events. The first of these was in May 1972, when a late-season snowstorm occurred after the samplers were placed in operation for the summer. The second event occurred in September 1973, when an early-season snowstorm occurred before the samplers were shut down for the winter. Only a trace of sediment was in the samples collected during the first snowmelt event; all the sediment was held in suspension, and no particles were visible to the naked eye. Sediment concentration in samples from the second snowmelt event averaged 400 mg/liter from the saline-upland range site and 70 mg/liter from the claypan range sites.

2. On both the claypan and the saline-upland range sites the sediment concentrations during midsummer thunderstorm events

tended to be highest at the beginning of the runoff event and to decline rapidly to a relatively constant concentration for the remainder of the event. In contrast, concentrations were lower and fairly uniform throughout both early- and late-season runoff events. This difference is probably related to the higher rainfall intensities and shorter durations associated with thunderstorm events.

Conclusion

Two conclusions may be reached from this study:

1. The chemical quality of surface runoff water from saline-upland and claypan range sites in southeastern Montana is good to excellent. It is, in fact, better than the quality of many municipal water supplies in the same area.

2. Erosion rates from these upland watersheds are well below acceptable limits and do not significantly contribute to downstream sediment loads. Downstream sediment yield apparently results from bank and channel erosion that occurs after surface runoff becomes concentrated and channelized in rates and amounts with sufficient erosive power for particle detachment and

transport.

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